1452

INTER-COMPANY CORRESPONDENCE

UNION CARBIDE NUCLEAR COMPANY

Division of Union Carbide Corporation

To: Safety and Health Physics Engineers and Surveyors

Plant: Oak Ridge Gaseous Diffusion

Date: April 20, 1959

Copies To: Dr. H. F. Henry

Subject: Continuous Air Monitor Operating Instructions and Calibration Data

Attached are data and basic information relating to the over-all counting and collecting efficiency, calibration procedures, and operating instructions for the subject instrument. Currently, 18 of these units are assigned to operating groups and 2 units are to be maintained by our groups to cover loans, replacements, and special survey requirements.

Items B and C in the attachment cover basic development criteria for initial calibration study; however, items D through G, inclusive, delineate calibration check procedure, operating instructions, and adjustments.

As in the past maintenance and repair work will be handled directly by the operating group involved. We will continue to be responsible for the following:

1. Field check during regular audits, noting time, date, instrument location, and operating condition.

2. Continue follow-up training with operating supervisors to acquaint them with calibrating and operating techniques.

3. Replacement of filter paper and register tapes monthly. A note should be made at appropriate place on tape reflecting any unusual operating condition, change in location, etc.

4. Identification of tape; signed by the auditor and forwarded to the records unit for file.

5. Liaison with Instrument and Engineering Department, and Stores Department to expedite repair, spare parts, etc.

AFB:la

A. F. Becher
Safety and Health Physics

Attachment
Continuous Air Monitor Calibration and Routine Operating Procedure - 4/16/59
No RC

CONTINUOUS AIR MONITOR CALIBRATION AND ROUTINE OPERATING PROCEDURE

A. Introduction

The continuous air monitor is designed to continuously collect 30-minute air samples, count the alpha particles emitted from the material collected, and record the results in terms of percent of the P.A.L. for air contamination due to uranium. (P.A.L. = 2 count/minute/ft.^{3} of air.) A five-hour delay between the beginning of sample collection and the end of a sample counting eliminates radiation background due to alpha particles which are emitted by the naturally occurring radon and thoron daughter products which are always present in the atmosphere in varying amounts.

The monitor is provided with two count-recording registers. A half-hour register accumulates the 30-minute "count rate" of the scaler and clears and prints this total in terms of COUNTS/MIN/CU FT each half-hour period. Whereas the eight-hour register accumulates, then clears and prints the average activity of the (16) half-hour samples taken during an eight-hour period in these same terms. Ample space is provided on the register tapes to make such notations as may be needed to identify locations sampled or conditions existing during sampling periods; the date and time the samples are collected is automatically recorded.

B. Experimental Determination of Counting Efficiency

1. The counting efficiency of the monitor was determined experimentally by releasing normal uranium as UO_3, UF_4, and UF_6 (to produce UO_2F_2) in an enclosed area and collecting air samples of each compound. The samples were counted on a "standard" air monitor and the counting rate thus obtained was compared with the disintegration rate of all of the material collected, as determined by an analysis of the "ashed down" samples; a 15% average counting efficiency for air samples was obtained for the "standard" monitor.

2. At this same time, a plated uranium "standard" one-inch in diameter and having a count rate of 5578 counts/minute was counted to provide a means for checking the counting efficiency of the monitor. The average count rate of 4527 counts/minute obtained indicated a counting efficiency of 81.2% for the monitors. Thus, the expected count rate for any comparable source will be 81.2% of the value shown on the source in counts/minute if the detector being checked has the same counting efficiency as the "standard" monitor. The air sample counting efficiency of other monitors is determined

by multiplying the experimentally determined efficiency of the "standard" monitor by the ratio of the actual and the expected count rates from a comparable standard plated film. (See attached sample calibration data sheets.)

C. Calibration

The performance of each monitor was checked initially against the "standard" instrument before the monitor was placed in field operation. Subsequent calibration checks are made at periodic intervals; the frequency of such checks depending upon operating experience. In general, weekly calibration checks are sufficient to assure dependable operation. The following procedure covers the proper method of making the original calibration and subsequent calibration checks of a typical air monitor.

1. Obtain an air-flow rate correction for rotameter readings, using the following method:

   a. Set the rotameter at two and read the vacuum gauge. Record both readings on the prepared calibration data sheet and repeat the process at rotameter settings of three, four, five, and six.

   b. Obtain pressure correction factors for each vacuum gauge reading and record.

   c. Multiply rotameter setting by the correction factor to obtain the true flow rate (record as Required Air Flow - F - Sample 1).

   d. Plot a curve of Rotameter Setting vs. Required Air Flow - F (Sample 2).

2. Determine the correct operating voltage and sensitivity settings. The sensitivity is set at one-fourth volt by the Instrument Shop and should not normally require changing; however, the point indicated on the calibrated dial should be recorded.

   Method:

   a. Check the detector tube height adjustment to assure that the window mounting ring is flush with the bottom of the holder.

b. Center the detector tube on the standard plated uranium source furnished with the monitor.

c. Set the scale factor on 64 and take a series of counts at detector voltages ranging from 850 to 1250. Normally, the operating voltage should never exceed 1250 volts.

d. Using the calibration data sheet, record detector voltage, register counts plus any remaining lights on the scaler, half-hour register counts, eight-hour register counts, scale factor, and counting time. All register counts should be essentially the same.

e. Using data obtained on the scaler, calculate the scaler total counts per minute (c/m) and plot alpha c/m vs. detector head voltage with voltage as the abcissa.

f. Select as the operating voltage a point which falls in the middle of the plateau of the curve (usually, this is about 1000 volts) and record.

g. Place the detector tube on a piece of clean paper and take a five-minute background count at the voltage selected in f. above. The background should not exceed about 0.2 counts per minute.

3. Obtain average counting rate of plated uranium standard.

Method:

a. Place the detector tube on plated standard making certain the standard is centered under the detector.

b. Count the standard four times (three-minute counts) at the selected operating voltage and sensitivity settings, record the data, and determine the average counting rate (C_2). The average count rate should be about 80% of the value shown on the standard.

c. Compute the acceptable range of C_2 for subsequent checks.

$$\text{Acceptable count range} = C_2 \pm 2\sqrt{C_2}.$$

4. Determine air monitor counting efficiency, G, (Sample 3).

Method:

a. Obtain the average counting rate (C_2) of the monitor for a one-inch diameter plated uranium standard (C_1).

b. Counting efficiency (G) of air monitor being calibrated is given by:

$$G = \frac{C_2}{0.812\ C_1} \times 0.15$$ where

C_1 = Counting rate of one-inch diameter uranium standard in counts/minute obtained by the "standard" instrument.

C_2 = Average counts/minute obtained on air monitor.

5. Determine flow rate (F) at which monitor must be set.

Method:

$$F = \frac{0.5662}{G}$$ where

G = Counting efficiency determined in 4. above.

6. Set rotameter at the proper flow as interpreted from graph of true air flow vs. rotameter reading.

D. Calibration Check (Sample 3)

Method:

1. Turn scaler high voltage switch to "off" position.
2. Disconnect high voltage lead to detector tube.
3. Remove sampler hood.
4. Remove detector tube and center it over the plated uranium standard provided.
5. Replace high voltage lead and turn high voltage to "on" position.
6. Adjust voltage to value shown on calibration log sheet.
7. Turn scale factor to 64.
8. Count the plated standard for ten minutes and calculate the average count rate. If the counting rate falls within the acceptable range recorded on the calibration log, no changes are required. However, if the counting rate does not fall within the acceptable range, enter the new rate under C_2 on the calibration log and calculate new values for acceptable range, counting efficiency, and air flow required.

f. Obtain the new rotameter setting from the air flow correction curve, record the value, and adjust the rotameter accordingly.

E. Operation

Air monitor start-up:

1. Scaler

Turn master and high voltage switch to "off" position and turn high voltage control to extreme left.

2. Registers

Turn on-off switches on both registers to "off" position.

3. Turn instrument switch located on pump end of monitor to "on" position.

4. Scaler

a. Turn master switch "on" and allow one minute for warm up.

b. Turn high voltage switch "on," wait until the meter needle moves upward, then set the detector voltage at the calibrated value by turning the voltage control to the right.

Caution: DO NOT EXCEED THE VOLTAGE AT WHICH THE MONITOR WAS CALIBRATED.

c. Set scale selector switch to 16.

d. Clear scaler by operating reset control and moving knurled wheel upward until the manual register on the scaler is at zero.

e. Turn the count switch to "on" position.

5. Registers

a. One-half hour register

(1) Turn on-off switch to "on" position.

(2) Push red button to actuate the printing mechanism. The time and accumulated count will be printed, the register will "clear," and the time wheels will advance one-half hour.

(3) Set printer to read five hours prior to the present correct time by actuating the manual control (red button). Example: If the correct time is 10:15 a.m., the last time printed should be 5:00 a.m. The first five printed represents 5:00 a.m., and the second five printed represents 5:30 a.m.

(4) Set the timer clock at the correct number of minutes beyond the hour. Example: If the correct time is 10:15 a.m., set the timer at 15.

b. Eight-Hour Register

(1) Turn on-off switch to "on" position.

(2) Depress red button to actuate printing mechanism. The time, date, and accumulated count will be printed, and the register will "clear."

(3) Set the time and date print wheels to read five hours prior to the present correct date and time by depressing the release lever on the side of the stamp and advancing the print wheel manually. The selected time should correspond to that of the one-half hour register.

(4) Set the timer clock to read the number of hours and minutes after the beginning of a shift, which is indicated by the time selected in (3) above. Shifts begin at 12 midnight, 8:00 a.m., and 4:00 p.m.

6. Set Air Flow Rate

a. Turn pump switch to "on" position.

b. Set rotameter to the value shown on the calibration log by adjusting the flow valve.

7. Check Pump Oil Level

See instructions printed on oil level indicator:

F. Changing Filter Papers: (Stores Catalog No. 15-157-0502)

1. Scaler

Turn master and high voltage switch to "off" position and turn high voltage control to extreme left.

2. Power Supply

Trip both power breakers to "off" position.

3. Detector Head

Unscrew and remove high voltage cable connection.

4. Aluminum Cover

Remove cover in a level position taking care to pull the air intake funnel away from the filter paper to avoid cutting the paper.

5. Installing New Roll of Paper

a. Loosen clamp nut located between the two sprocket chain drives on the paper take-up end.

b. Slide slotted bracket located between the two chain sprockets clear of take-up reel shaft.

c. Pull roll of used paper and drum out of the slot and remove chain from sprocket.

d. Clear the drum of used paper.

e. Insert paper drum back in position by reversing the removal procedure.

f. Loosen tension rubber guide rollers at paper drive drum.

g. Pull paper holder and paper spool out of the slot on the inlet end of the paper drive unit.

h. Install new roll of paper so it unwinds upward from the outside, positioning it so it unwinds clockwise with the paper coming off of the bottom of the roll.

i. Feed the paper over the guide roller, under and up around the suction head, then over the top of the support rod and between the shelf and scintillator tube. Pull about eight inches of slack in paper and feed end of paper around paper drive drum and then over the guide roller. Tighten guide rollers just enough to hold paper on drum. Place end of paper on the center of the take-up drum and attach with tape removing any slack in paper. Manually actuate paper drive ratchet relay two or three times to ascertain if paper drive is operating satisfactorily. Reposition paper alarm trolley shoe and make certain it is riding on surface of the paper.

j. Re-install cover being careful to avoid damage to paper; reconnect high voltage lead to detector head.

6. Removal of Register Tapes at the Close of Each Calendar Month

   a. Wind the balance of the paper tape until all printed matter is on rewind spool.

   b. Cut tape off where it leaves the paper guide.

   c. Remove clip from tape spool on lower left-hand side and carefully slide tape from spool.

7. Replacement of Register Tape

   a. Remove tape roll retainer wing nut on lower right-hand side of spool and remove any remaining tape.

   b. Install new tape roll on spool so that tape unwinds in a clockwise direction and replace wing nut and tape retainer.

   c. Insert tape within flanges of paper guide.

   d. Place tape between tape feed rollers with approximately a six-inch leader strip.

   e. Wind tape once around lower left-hand spool and slip tape clip in groove with paper between spool and clip.

G. Routine Check List (Check each shift)

1. See that filter paper is not broken; this should be detectable by activation of the alarm bell mounted underneath the top shelf. Rethread if necessary.

2. The following should correspond to data shown on the calibration sheets:

   a. High voltage setting.

   b. Scale factor (16).

   c. Rotameter setting.

3. Count switch should be in "count" position.

4. Pump and instrument switches should be in "on" position.

5. Oil in pump reservoir should be in accord with instructions printed on oil reservoir. Service with S.A.E. No. 10.

6. Time registered on recorded tape should be five hours earlier than the correct time.

7. Check the half-hour recorder tape. If a series of readings show no variation, the instrument is not operating properly and any of items 1 through 4 above could be at fault.

8. Date and time registered on eight-hour recorder at the last time shown should be the end of the previous shift, i.e., 4:00 p.m., 12 midnight, or 8:00 a.m.

9. Note any change in location of the sampler at the appropriate place on the register tape, as well as any unusual condition such as power failure, instrument repair, replacement of tape, etc.

Attachments:
Sample Calibration Sheets (Samples 1-4)

Safety and Health Physics
Industrial Relations Division
April 16, 1959

SAMPLE 1

CALIBRATION DATA

Continuous Air Monitor Serial No. 10 Date: 11/4/58

Calibrate on scale of 64 - Operate on scale of 16 By: U. Man

Detector Voltage	Scaler		1/2-Hour Register Counts	8-Hour Register Counts	Scale Factor	Counting Time - Minutes	Scaler Total c/m
	Register Counts	Number Lights					
Response Curve							
850	131	31	131	131	64	3	2805
900	198	8	198	198	64	3	4227
950	205	10	205	205	64	3	4377
1000	206	6	206	206	64	3	4397
1050	205	17	205	205	64	3	4379
1100	206	21	206	206	64	3	4401
1150	207	52	207	207	64	3	4433
1200	256	33	254	253	64	3	5472
1250	375	27	343	355	64	3	8009
Average Counting Rate - C_2							
1000	206	10			64	3	4398
1000	206	48			64	3	4411
1000	205	51			64	3	4390
1000	207	0			64	3	4416
						AVERAGE C_2	4404

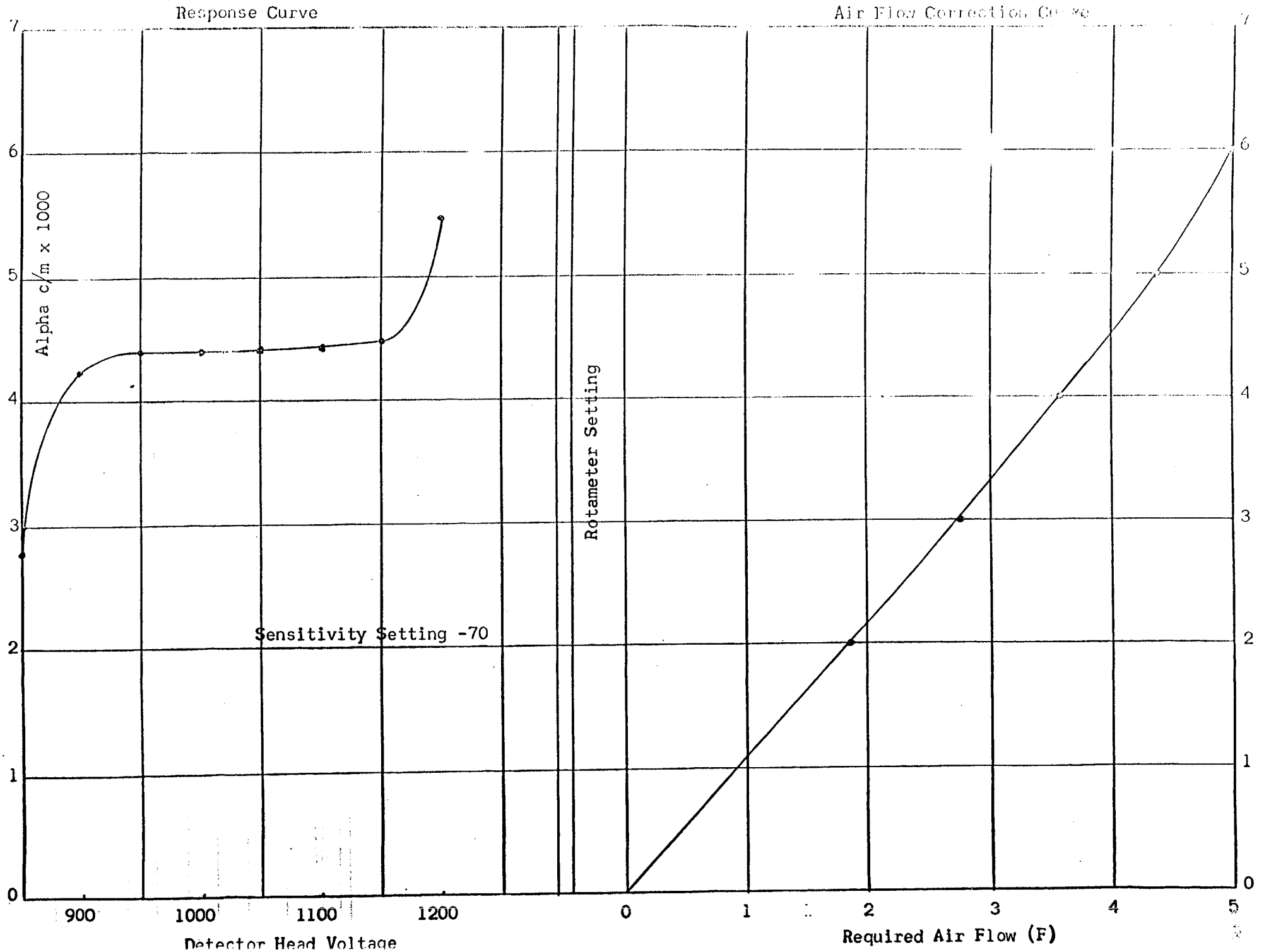
Source No. 2096 Detector Head No. 836

Activity 5587 c/m Sensitivity Setting 70

Rotameter Setting	Vacuum Gauge Reading	Correction Factor	Required Air Flow - F (True Flow Rate)
Air Flow Rate Correction Curve			
2	2.75	0.943	1.9
3	3.75	0.924	2.8
4	5.10	0.898	3.6
5	6.40	0.872	4.4
6	7.90	0.842	5.1

Safety and Health Physics
Industrial Relations Division
April 16, 1959

SAMPLE 2


Response Curve
Alpha c/m x 1000
Sensitivity Setting -70
Detector Head Voltage
900
1000
1100
1200
0
1
2
3
4
5
6
7
Air Flow Correction Curve
Rotameter Setting
Required Air Flow (F)

SAMPLE 3

CALIBRATION LOG

Continuous Air Monitor Serial No. 10

Calibrate on scale of 64 — Detector Operating Voltage 1000

Operate on scale of 16 — Detector Head No. 836

Date	Alpha c/m		Calibration Check Acceptable Range		Counting Efficiency G	Air Flow (CFM)	
						Required F	Rotameter Setting
	C_1	C_2	$C_2 + \sqrt{C_2}$	$C_2 - 2\sqrt{C_2}$			
11-4-58	5587	4404	4537	4271	0.146	3.88	4.3
12-4-58	5587	4387	Calibration	check - no	change required.		
1-4-58	5587	4500	Calibration	check - no	change required.		
2-4-58	5587	4200	4330	4070	0.139	4.07	4.46

C_1 = Counting rate of one-inch diameter plated uranium standard.

C_2 = Average counting rate obtained on monitor for above standard.

G = Calculated counting efficiency.

F = Required air flow.

Formulas: $G = \frac{C_2}{0.812\ C_1} \times 0.15$

$F = \frac{0.566}{G}$

Safety and Health Physics
Industrial Relations Division
April 16, 1959

SAMPLE 4

CONTINUOUS AIR MONITOR - PRESSURE CORRECTION FOR ROTAMETER

In. Hg Vacuum	Correction Factor	In. Hg Vacuum	Correction Factor
0.00	0.990	5.25	0.895
0.50	0.982	5.50	0.890
1.00	0.975	5.75	0.886
1.25	0.970	6.00	0.881
1.50	0.967	6.25	0.876
1.75	0.963	6.50	0.871
2.00	0.958	6.75	0.867
2.25	0.953	7.00	0.862
2.50	0.949	7.25	0.857
2.75	0.945	7.50	0.852
3.00	0.940	7.75	0.847
3.25	0.935	8.00	0.842
3.50	0.930	8.25	0.837
3.75	0.925	8.50	0.831
4.00	0.920	8.75	0.827
4.25	0.915	9.00	0.820
4.50	0.910	9.25	0.815
4.75	0.905	9.50	0.810
5.00	0.900	9.75	0.805
		10.00	0.800

Safety and Health Physics
Industrial Relations Division
April 16, 1959